Status of Biological Control of Tropical Soda Apple, *Solanum viarum,* in Florida[1]

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INTRODUCTION: Tropical soda apple (TSA), *Solanum viarum* Dunal (Solanaceae), a perennial prickly weed native to South America (Fig. 1), has been spreading rapidly in the USA since it was discovered in Glades County, Florida in 1988. In Florida, approximately 150,000 acres (60,704 ha) of pasture land were infested in 1992 (Mullahey *et al*. 1993). Currently, the infested area is estimated at over 1 million acres (404,694 ha). TSA also invades hammocks, ditch banks, citrus groves, vegetable fields, sugarcane fields and roadsides. TSA also has been reported in Alabama, Georgia, Louisiana, Texas, Mississippi, North Carolina, South Carolina, Tennessee, Pennsylvania and Puerto Rico (Bryson and Byrd Jr. 1996; Dowler 1996; Mullahey *et al*. 1997; Phil Lewis personal communication). TSA was placed on the Florida Noxious Weed List in 1994, and the Federal Noxious Weed List in 1995, and is listed as one of the most invasive species in Florida by the Florida Exotic Pest Plant Council (1999) (Fig. 2).

Fig. 1. Tropical soda apple. (Photography credit: J. Mullahey, UF-IFAS.)

Fig. 2. Tropical soda apple in South Florida. (Photography credit: J. Lotz, DPI.)

The invasiveness of TSA is attributed to several characteristics. A single plant produces about 150 fruits per year, and each mature fruit contains about 400 seeds. Up to 60,000 seeds are produced per plant with a germination rate of at least 75% (Mullahey *et al*., 1993, Pereira *et al*., 1997). Cattle and wildlife (birds, deer, feral hogs, raccoons) are the primary means of dispersal. The undigested seeds are spread by passage through the animals' digestive tracts. TSA also propagate vegetatively from root buds that regenerate new shoots.

DESCRIPTION OF THE PLANT: TSA is an herbaceous perennial plant that can grow up to 2 m (6 ft in height), but is usually not much more than 1 m (3 ft) tall in Florida. Plants are as broad as tall. Stems are sturdy and bear scattered small prickles, both straight and hooked (Fig. 3). Leaves are simple, lobed and alternate; to 20 cm (8 in) long and 15 cm (6 in) wide; and covered with fine soft hairs that give a velvety sheen to the upper surface of the leaves (Fig. 3). Some of these hairs are glandular with drops of sticky fluid on their tips that give the leaves a 'clammy' feel. The lower leaf surface is covered by stellate hairs. Prickles up to 2 cm (3/4 in) are found on the major veins of both leaf surfaces and are concentrated on the petioles. Hidden under the leaves are the white flowers (which resemble tomato flowers in shape) with reflexed petals and cream-colored anthers (Fig. 3). Immature fruits are pale green with dark green stripes and resemble tiny watermelons. Mature fruits are dull yellow, and to about 3 cm (1 1/5 in) wide, and are more visible after leaf drop (Fig. 4).

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Fig. 3. Tropical soda apple stems, leaves and flowers. (Photography credit: J. Lotz, DPI.)

Fig. 4. Tropical soda apple with immature and mature fruits. (Photography credit: J. Lotz, DPI.)

BIOLOGICAL CONTROL OF TROPICAL SODA APPLE: For the last decade chemical herbicides and mowing were used with limited success to control TSA. These control tactics provided only a temporary solution, and in addition to being expensive, they cannot be used in rough terrain or inaccessible areas. A biological control project on this invasive non-native weed was initiated in January 1997 by Drs. Julio Medal and James Cuda (University of Florida) in collaboration with Dr. Robinson Pitelli (Universidade Estadual Paulista, Jaboticabal Campus, Sâo Paulo, Brazil), and Daniel Gandolfo (USDA-ARS South American Biological Control Laboratory, Argentina). The FDACS/DPI and the USDA/APHIS/PPQ provided funding for this project.

From exploratory surveys conducted in Brazil, several insects were identified as potential biological control agents of TSA. Two leaf beetles, *Gratiana boliviana* Spaeth and *Metriona elatior* Klug (Chrysomelidae), were initially selected for screening because of the extensive plant defoliation attributed to these beetles in their native range (Medal *et al*. 1996). Two other promising candidates that are currently undergoing host range determination in Florida are the leaf beetle *Platyphora sp*. (Chrysomelidae) and a flower bud weevil, *Anthonomus tenebrosus* Boheman (Curculionidae) (Medal *et al*. 2002).

The South American Leaf Beetle, *Gratiana boliviana* (Coleoptera: Chrysomelidae). This beetle (Figs. 5, 6) is native to South America (Medal *et al*. 2002). Its life cycle begins when females deposit eggs individually on tropical soda apple leaves and petioles. Females produce an average of 300 eggs. The egg stage lasts 5-6 days at 25°C. The larval stage is completed in 15-18 days, and there are five instars. The pupal stage usually lasts 6-7 days. In total, 26 to 31 days are required for the insect to develop from the egg to the adult stage. *Gratiana boliviana* was approved for field release in Florida by the TAG (Technical Advisory Group for Biological Control Agents of Weeds) in April 2002, and a high level of specificity and substantial defoliation of TSA were demonstrated in host-specificity tests and field surveys conducted with this leaf beetle. Field release in Florida began in May 2003 in Polk County and June 2003 in Alachua County.

The Brazilian Leaf Beetle, *Metriona elatior* (Coleoptera: Chrysomelidae). Field surveys conducted in Argentina, Brazil, Paraguay and Uruguay during 1997 to 2001 indicated that *Metriona elatior* (Fig. 7) is highly-specific to TSA with no record of attacking Solanaceous crops in South America (Medal *et al*. 1999). The feeding oviposition tests conducted at the Florida Biological Control Quarantine Laboratory (FBCL) indicated that *Metriona elatior* is an herbivore with a narrow host range. This beetle feeds on a few weedy *Solanum* species, including *Solanum torvum* Sw and *Solanum tampicense* Dunal. These two exotic weeds are of increasing concern in the southeastern U.S. due to their potential to invade wildlife areas and displace native vegetation. *Metriona elatior* also fed and developed on eggplant *(Solanum melongena* L.) in small caged tests under laboratory conditions. These results were contrary to those obtained in open-field tests conducted in Brazil and Argentina, which had indicated that eggplant is not an alternate host of this insect. Additional screening tests are underway in the FBCL and in South America.

The Flower Bud Weevil, *Anthonomus tenebrosus* (Coleoptera: Curculionidae). The flower bud weevil, *Anthonomus tenebrosus*, is about 2 mm in length (Figs. 8, 9). This tiny weevil feeds and usually lays a single egg inside the TSA flower bud. Feeding damage by the larva developing inside the flower bud results in no fruit development. The complete life cycle of this insect is currently being investigated. Feeding and oviposition tests (multiple-choice and no-choice) are in progress at the FBCL. Research efforts have been initiated to develop an artificial diet for mass rearing of this potential biocontrol agent. Host-range tests should be concluded during 2003, and a petition for field release will be submitted if the additional tests corroborate the specificity and safety of this insect.

The Tropical Soda Apple Leaf Beetle, *Platyphora* sp. (Coleoptera: Chrysomelidae). The leaf-beetle *Platyphora* sp. (Figs. 10, 11) is another potential biocontrol agent for TSA that is currently being evaluated in quarantine. The adults are generally bright metallic green and about 1-1.5 cm in length. The immature or larval stages are cream colored with dark legs. Both stages are

Fig. 5. *Gratiana boliviana* adult. (Photography credit: J. Lotz, DPI.)

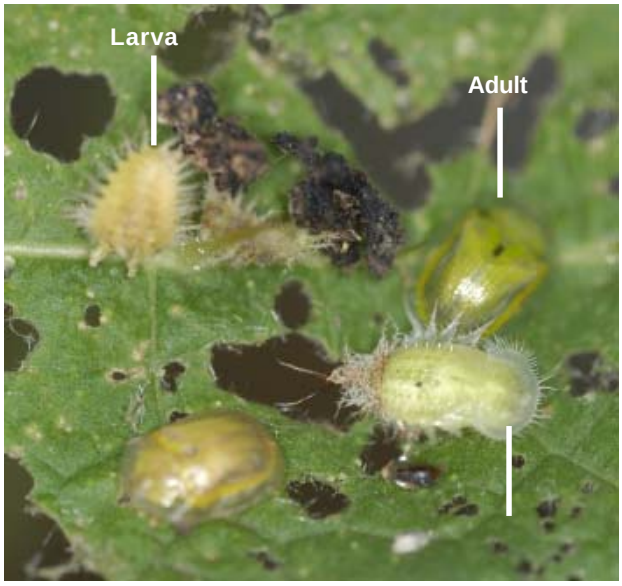

Fig. 6. *Gratiana boliviana* (larvae, pupa & adults) feeding on tropical soda apple. (Photography credit: J. Lotz, DPI.)

nocturnal feeders and can cause significant defoliation to TSA plants. The female deposits or lays second-instar larvae (larviposition) on the leaves of the host plant. Host specificity tests with this beetle are in progress, and a petition for field release will be submitted to the TAG probably at the end of 2003.

EXPECTED IMPACTS ON TROPICAL SODA APPLE POPULATIONS: A combination of biocontrol agents attacking different parts of the plant (leaves, flowers, fruits) will stress the TSA plants, making them less competitive in Florida's pastures. Once one or more of the biocontrol agents become established in the field, increase their populations, and cause significant damage to the TSA, an environmentally safe and self-sustainable long-term solution to the TSA problem may be finally realized.

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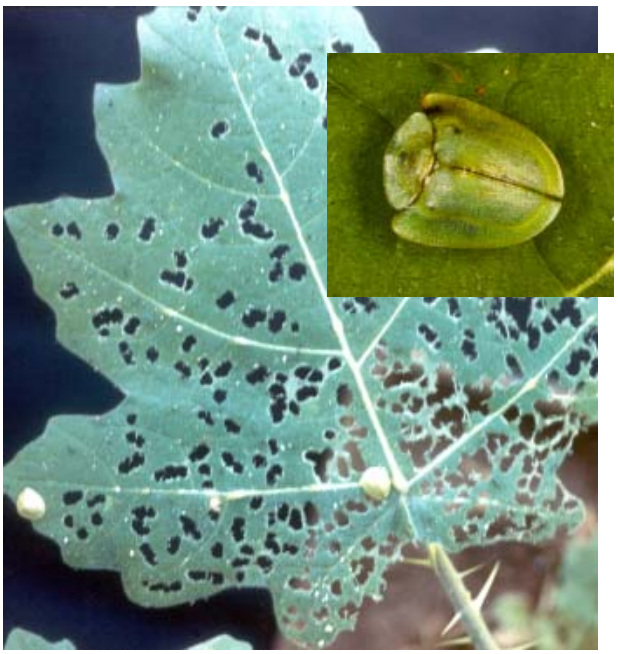

Fig.7. *Metriona elatior* adults feeding on tropical soda apple. (Photography credit: R. Pitelli, UEP-Jaboticabal, Brazil.) Inset: closeup of *Metriona elatior.* (Photography credit: J. Lotz, DPI.)

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Fig. 8. Flower-bud weevil adult. (Photography credit: S. McJonathan)

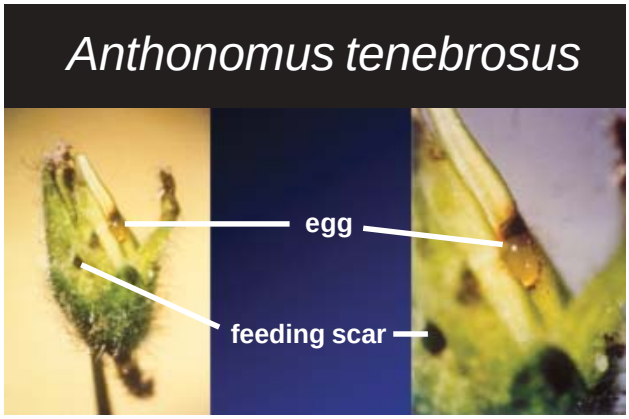

Fig. 9. Egg and feeding scars of the flower-bud weevil. Photography credit: D. Gandolfo, USDA-ARS.)

Fig. 10. *Platyphora* sp. adults. (Photography credit: J. Medal, UF.)

Fig. 11. *Platyphora* larva. (Photography credit: J. Lotz, DPI.)